5.2 PERSONNEL SELECTION, QUALIFICATION, TRAINING, AND STAFFING PROGRAM. The purpose of the program is to establish (develop and document) the selection, qualification, training, and staffing requirements for personnel such that persons are qualified to carry out their assigned responsibilities, that they have a broad understanding and acceptance of the inherent risks involved with the operations, and that they maintain a job performance proficiency consistent with effective control of the hazards and risks associated with the operations. Three broad categories of the program are considered in this guide. The categories are (1) the operations and support personnel associated with fissionable material operations outside of reactors, (2) the installation nuclear criticality safety staff, and (3) visitors and clerical employees. The personnel selection criteria and depth and breadth of nuclear criticality safety training are necessarily variable, depending on the work assignments of personnel. The ensuing discussion in this section is intended to provide guidance for organizations establishing new programs or improving current programs. This guidance is presented in an *a posteriori* form, expressly to emphasize that the specificity of structure and nomenclature for personnel selection, qualification, training, and staffing is illustrative and suggestive rather than recommendatory. General requirements of the program are provided in the applicable documents listed in sections 2.1.9 and 2.3.1.12.

5.2.1 Program for Operations and Support Personnel. The category of operations and support personnel includes fissionable material handlers and their supervisors, operations support, design, maintenance, technical support (including the members of the Nuclear Criticality Safety Organizations) and emergency response personnel, managers and other administrative personnel, and persons who enter areas where fissionable material is processed, stored, or handled. Guidance for the selection, qualification, training, and staffing requirements of these persons is provided in Chapter IV of DOE Order 5480.20 and ANSI/ANS-8.20-1991. As consistent with job assignments and personnel acknowledgement of job hazards and risks, the following elements should be considered for inclusion in the training and qualification program.

5.2.1.1 Continuing proficiency of personnel. Establish the training and qualification program to provide continuing proficiency of personnel. Tailor the program to job responsibilities, conduct of the job, recognition of hazards, and acceptance of risk. Establish requirements of refresher training to be provided at least every two years.

5.2.1.2 Nuclear fission chain reactions and accident consequences. Discuss the concept of a nuclear fission chain reaction. Make a distinction among families of chain reactions in which fission rate decreases with time, those that are sustained with a constant fission rate, and those that have an exponential increase in the fission rate.[8] Describe the time history of super-critical excursions for both metal (fast neutron) systems and for moderated (slow neutron) systems.[9] Include information about the kinetic energy release during the fission burst and compare it to the equivalent energy measured in familiar events; for example, chemical explosions.[10] Distinguish between the initial, the delayed, and possible radiation doses from criticality accidents in light of

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[8] ANSI/ANS-8.20-1991, "Nuclear Criticality Safety Training," paragraph 7.1.1.

[9] ANSI/ANS-8.20-1991, "Nuclear Criticality Safety Training, paragraph 7.1.2.

[10] ANSI/ANS-8.20-1991, "Nuclear Criticality Safety Training," paragraph 7.1.2.1.

expected doses at various distances from the source of the criticality as influenced by the rapidity of evacuation. Discuss health effects of criticality accidents.

5.2.1.3 Neutron behavior in fissioning systems. Describe neutron induced fission, neutron capture, and neutron scattering and leakage.[11] Discuss the influence of neutron energy on the fission probability.[12] Explain neutron moderation as the mechanism that reduces the neutron energy.[13] Identify several good neutron moderators. Discuss the use of neutron absorbers (poisons) with emphasis on caveats when relying upon soluble neutron poisons.

5.2.1.4 Criticality accident history. Review and describe selected criticality accidents. Include a discussion of the causes of the accidents and their terminations.

5.2.1.5 Response to criticality accident alarm signals. Train personnel in the recognition of, and the response to, criticality accident alarms and the relationships of distance, time, and shielding to the reduction in a received radiation dose.

5.2.1.6 Nuclear criticality safety parameters. Explain and illustrate the influence of various nuclear criticality safety parameters on process safety. These include mass, geometry, interaction/separation, moderation, reflection, concentration, volume, density, neutron poisons, heterogeneity, and enrichment. Illustrate the concept of contingencies (i.e., the loss of a nuclear criticality safety parameter control) by examples pertinent to facility operations. Review and discuss facility single parameter limits.

5.2.1.7 Policy and procedures. Describe the facility management's nuclear criticality safety policy and include discussions about the use of operational and facility configuration control procedures for the control of nuclear criticality safety parameters. Inform employees of their right to question any operations that they believe may not be safe.

5.2.1.8 Evaluations. Periodically, perform and document evaluations of the training program and trained personnel. Retain documentation of the evaluations in accordance with DOE Order 1324.2A and DOE Order 5480.20.

5.2.2 Installation Nuclear Criticality Safety Staff. This category includes the manager and members of the installation Criticality Safety Organization who are responsible for performing computational or comparative evaluations and safety analyses for fissionable material operations; for developing procedural, process, and control requirements; and for providing procedural, process, and equipment/facility reviews and approvals, nuclear criticality safety training program development, and facility operational reviews, appraisals, audits, and investigations. Broad personnel selection, qualification, training, and staffing requirements are provided in the applicable

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[11] ANSI/ANS-8.20-1991, "Nuclear Criticality Safety Training," paragraph 7.2.1.

[12] ANSI/ANS-8.20-1991, "Nuclear Criticality Safety Training," paragraph 7.2.2.

[13] ANSI/ANS-8.20-1991, "Nuclear Criticality Safety Training," paragraph 7.2.3.

document listed in section 2.1.9. The professional personnel charged with implementing the programs identified in this standard are designated nuclear criticality safety specialists (NCSS).

Qualifications include the following requirements or required actions:

1. A demonstrated capability to perform installation-specific analyses (and, if appropriate, facility-specific analyses) of the NCSS job and its tasks.

2. Complete a qualification checklist, file, card, or other task fulfillment that identifies each applicable task and the method(s) by which competence is to be demonstrated, and that provides for confirmation.

3. Possess a baseline education of a baccalaureate degree in engineering or science and a minimum experience in nuclear criticality safety at the facility of one (1) year to independently perform NCSS tasks (e.g., be classified as a Specialist), and three (3) years to provide independent review and quality assurance of NCS tasks (e.g., be classified as a Senior Specialist). Equivalencies may be established.

4. Serve an apprenticeship for inexperienced new-hire personnel with performance evaluation based on actual or representative work products.

5. Provide a qualification-by-documentation for existing and experienced new-hire NCSS personnel.

6. Confirm final qualification by line and safety management.

7. Continue competence confirmation based on practical exercises in one or more of the four functional specialties (see section 5.2.2.1) consistent with their responsibility and level of activity in each area.

Qualification options include:

1. Modes --
   a. Formal training (onsite and offsite),
   b. Apprenticeship and structured on-the-job training, and
   c. Professional development activities.

2. Classification levels consistent with responsibilities and authorities assigned --
   a. Entry-Level,
   b. Apprentice,
   c. Specialist,
   d. Senior Specialist, and
   e. Lead Specialist.

3. Functional specialization, which may be divided into the following generic, or any other set of installation/facility-specific, categories:
   a. Analysis,
   b. Evaluation,
   c. Implementation, and

d. Confirmation.

4. Overall qualification requirements, that depend on both the classification level and the functional specialization.

5. Separate qualification, that may be required for individual facilities.

For the purposes of this section, nuclear criticality safety specialists (NCSS) are collectively the professional staff with primary responsibility for implementing the activities and programs required to support this standard. As defined below, the job designation, "Specialist," is that of the baseline individual capable of performing independently (perhaps in a designated functional area). The more highly qualified Senior Specialist has additional responsibility for providing independent review and oversight. The titles are functional and, therefore, independent of site-specific human resource designations that may include engineer, senior engineer, etc., and may have intermediate classifications.

This section provides guidelines for judging initial qualification and continuing competence of nuclear criticality safety specialist personnel. DOE Order 5480.20, "Personnel Selection, Qualification, Training, and Staffing Requirements at DOE Reactor and Non-Reactor Nuclear Facilities" (2-20-91), does not address qualification for the NCSS position specifically. However, this Order does address qualification requirements for positions that have similar and related responsibilities (as described in section 5.2.2.2.5).

Engineers and other personnel assigned a limited number of tasks related to nuclear criticality safety, and technicians performing routine tasks under direct guidance from nuclear criticality safety specialists (e.g., audits using a checklist, computer testing, etc.) are excluded from this standard. However, all shall be qualified for the tasks they perform and may participate in appropriate portions of the program described herein.

The qualification processes described in this section require documentation and management approval for qualifying NCSS personnel. Qualification ultimately is the responsibility of management, which shall also address personal characteristics of maturity, judgment, decision-making ability, independence, and teamwork.

This qualification process allows for specialization in one or more of four functional specialties in the nuclear criticality safety discipline and assumes the ability and availability for an anticipated mode-of-progression in job responsibilities from Entry-Level to Senior Specialist followed by on-going demonstration of continuing competence

5.2.2.1 Functional specialties. As noted in the applicable documents above, all nuclear criticality safety specialists are considered to be personnel who are

- familiar with the physics of nuclear criticality and with associated safety practices to furnish technical guidance to management appropriate to the scope of operations;

- skilled in the interpretation of data pertinent to nuclear criticality safety and familiar with operations to serve as advisors to supervision;

- involved in technical support functions of surveillance, of analyzing facility data, planning modifications, reviewing programs, and resolving technical problems within the area of nuclear criticality safety; and

- having the responsibility and authority to comment on, or review and concur with, nonreactor nuclear facility fissionable material operating processes and equipment.

Thus, collectively, each requires competence in physics of nuclear criticality, associated safety practices, and familiarity with facility operations. However, individual specialists may be qualified to meet all responsibilities or may have specialization consistent with the collective competence of the entire organization. This section allows for, but does not require, broad specialization consistent with traditional nuclear criticality safety practices. The following generic areas are addressed:

1. (Safety) Analysis -- performing design analysis for processes and equipment and for integrated safety assessment with attention to nuclear criticality safety.

2. Evaluation -- performing the unique subset of (safety) analysis that deals with computer and other evaluations for system subcriticality (subsequent use of the term analysis/evaluation reflects the interrelationship between the two functions).

3. Implementation (Administration) -- providing administrative interface for integrating analysis/evaluation with facility operations and practices (e.g., procedures, specifications, postings, and training) and for meeting regulatory and other requirements.

4. Confirmation -- performing audits and other assessments of compliance with analysis/evaluation requirements and conditions, regulatory requirements, and other requirements.

The four basic functional categories (analysis, evaluation, implementation, confirmation) are described in more detail in the following sections, but they are quite arbitrary, both in name and content. They represent overlapping functions requiring each nuclear criticality safety specialist to have common baseline knowledge of all responsibilities. An analysis of the nuclear criticality safety specialist responsibilities and tasks will be necessary to define common baseline requirements, name and define each functional specialty (if used), and establish qualification requirements including education, experience, classroom, and on-the-job training.

Each of the four generic functional specialties and the continuing competence to perform NCSS tasks (whether divided among the analysis, evaluation, implementation, and confirmation functions) is described below.

5.2.2.1.1 Analysis. Analysis, according to this standard, is a thorough description -- developed by non-reactor nuclear facility safety management, engineering design personnel, and facility operations supervision -- that includes sufficient facility, equipment, and fissionable material process descriptions and controls to permit the identification of normal and abnormal conditions and means of attaining those conditions. This will enable performance of a safety analysis specific to nuclear criticality that identifies contingent conditions (potential criticality scenarios) and the bases for subcriticality (nuclear criticality safety evaluation) and for nuclear criticality safety (NCS).

Alternatively, (safety) analysis is the documented process to systematically identify the hazards inherent in an operation; describe and analyze the adequacy of the measures taken to eliminate, control, or mitigate identified hazards; and analyze and evaluate potential accidents and their associated risks. Criticality safety analysis is an important aspect of this in non-reactor nuclear facilities. The NCSS provides unique attention to this aspect.

A third definition is that accident analysis is analysis and documentation of the technical bases for determination of safety classification of systems, structures, or components to provide the technical bases for technical safety requirements (TSR), or to support a conclusion that an operation can be conducted without undue risk to the public, workers, or the environment.

This analysis includes

(a) modelling facility response to accident conditions and performing related studies or calculations,

(b) documenting and reviewing calculations used in safety analyses, and

(c) coordinating specialized assistance from safety specialty analysts; these latter safety specialty analyses are analytical determinations that include

- performance and review of special safety analyses and computer code development and validation related to these calculations, including risk assessment, radiation dose consequence analysis, and criticality analysis;

- preparation and review of safety analysis report chapters, or portions thereof, that relate to specialty skills; and

- specialty project assignments that require specific skills and/or qualifications that an individual possesses.

5.2.2.1.2 Evaluation. Evaluation, according to this standard, is a documented demonstration of the technical computational basis or comparative evaluation with experimental data that provides the subcritical operating values in support of the nuclear criticality safety analysis. An evaluation is a subset of an analysis. It frequently is treated as a separate function based on precedent and due to the unique need for, and substantial attention directed toward, demonstrating subcriticality for normal, upset, and accident situations and configurations identified in safety analyses. Also of importance is maintaining and validating the computer codes and systems used for this purpose. Where evaluation may be a dominant facet of nuclear criticality safety analysis, it does not by itself constitute safety analysis.

5.2.2.1.3 Implementation. Implementation is the process of bringing into existence engineered safety features, parameter limits, and other controls for criticality safety. It includes most of the nuclear criticality safety activities other than those directly involved in performing safety analysis and evaluation (and the specific confirmation activities described next). An important ingredient is providing advice to, or otherwise assuring appropriate attention of, management and supervision on their numerous and diverse responsibilities regarding maintaining engineered safety features, keeping parameters within limits, and enforcing other controls for criticality safety. Another ingredient is providing needed administrative interface to the other functions, such as integrating

the analysis/evaluation inputs and outputs with facility operations (e.g., work practices, procedures, specifications, postings, and training) and identifying audit needs and responding to identified deficiencies. A major responsibility is ensuring that regulatory and other requirements (e.g., demonstration and documentation of double-contingency) are met.

5.2.2.1.4 Confirmation. Confirmation includes performing audits and other assessments of compliance with conditions used in, and specified as a result of, the analysis/evaluation processes, with regulatory requirements and with other requirements. As deviations and associated trends are identified, corrective actions may be developed jointly with facility management as part of the implementation function.

5.2.2.1.5 Continuing competence. Continuing competence consists of maintaining the ability to perform the NCSS tasks whether they are divided functionally among analysis, evaluation, implementation, and confirmation.

5.2.2.2 Qualification process. This section provides guidelines for judging competency and determining qualification of nuclear criticality safety specialist personnel. It describes the overall approach, mode-of-progression, functional breakdown, and requirements.

The qualification process described herein requires documentation and management approval. Thus, it is a form of certification. However, the term is avoided here because DOE Order 5480.18 defines certification as being the product of an accredited, performance-based training program. Although not necessarily accredited, the underlying principles of performance-based training do apply to this training program.

The requirements of this standard also apply to temporary or consultant personnel who serve as NCSS or perform major NCSS tasks (e.g., evaluations of subcriticality). They should meet the qualification requirements consistent with the tasks assigned (i.e., Apprentice if performing under supervision, Specialist if working independently, and Senior Specialist if providing review and oversight).

5.2.2.2.1 Principles. The qualification process applies to both new personnel and those currently serving as NCSS. In the latter case, there is no "grandfathering" per se, but rather a qualification-by-documentation process. At the time the standard takes effect at a facility, incumbents may be assumed to be qualified to fulfill current job responsibilities. They verify the qualification by documenting how each major set of task items was met, addressing any deficient areas with training or practical exercises, and meeting the continuing competence requirements (as outlined in section 5.2.2.5) on an established schedule. The qualification process does not apply to consultants and temporary personnel under direct guidance, surveillance, and performance or task acceptance review from qualified nuclear criticality safety specialists for specifically directed tasks (e.g., audits, computer testing, etc.).

Qualification is judged based on a combination of education, experience, training, and professional development. The training consists of formal classroom activities and structured on-the-job training (OJT) that stresses actual work performance under close guidance from a Senior Specialist and detailed evaluation of, and feedback on, work products.

This section describes processes for qualification of NCSS personnel that are necessary, but not, by themselves, sufficient. Qualification is the ultimate responsibility of management who shall address other factors such as maturity, judgment, decision-making, independence, and teamwork.

An anticipated mode-of-progression has all incoming personnel progressing from Entry-Level to Apprentice, to Specialist, and finally to Senior Specialist. This approach enhances overall organization capability. From a human resource perspective additional levels may be used to reflect factors such as experience, maturity, and overall unique value to the organization.

An additional level, Lead Specialist, is supervisory in nature. Because assignment is based on a variety of factors including availability, it is not part of the mode-of-progression.

The qualification program sets standards and minimum times for promotion to higher levels. Management also may establish maximum times consistent with reasonable progress in meeting applicable requirements. Failure to qualify within allotted times may result in reassignment or other action.

Each facility should perform an analysis of the NCSS job requirements and identify associated tasks. This is similar to, but less detailed than, the job/task analysis (JTA) used in development of performance-based training programs (see section 2.1.7). The facility-specific task list is generated based on job descriptions, tasks identified in this standard, and other resources. The task list may be used to define either a single NCSS position or specialty functions (e.g., analysis, evaluation, implementation, and confirmation). The list is also the basis for developing the behavioral objectives that define and measure performance for the qualification program. With functional specialization, minimum qualification levels are established in the specialty, related, and interface areas.

Qualification requirements are a combination of education, experience, formal training, structured on-the-job training, professional development, and personal factors or characteristics. Minimum standards are established in each area. However, equivalencies are appropriate and should be predetermined and specified in general terms in the qualification procedure. One example is the type and extent of experience that would be considered in lieu of a technical degree. Another example is to consider certain advanced degrees or specialized research projects to be equivalent to an amount of criticality safety experience.

5.2.2.2.2 Classification levels. The anticipated mode-of-progression begins at the Entry-Level for personnel newly hired to become nuclear criticality safety specialists. They are designated as Apprentices after having completed specified requirements and having been judged ready to perform work under supervision of a Senior Specialist. The designation "Specialist" applies when the individual is deemed capable of performing independently (perhaps in a designated functional specialty area). A Senior Specialist is more highly qualified and judged to be prepared for the additional responsibility of providing independent review and oversight and to be a Senior Specialist for apprentice-level personnel. A Lead Specialist designation applies to supervisory/management functions that are outside of the mode-of-progression, with availability depending on staffing levels, organization structure, vacancies, etc.

The titles are generic. Equivalent designations may be used at a given facility. The titles also may be separate or independent of site-specific human resources designations that may include

engineer, senior engineer, etc. and may have intermediate (e.g., Specialist I, Specialist II, and Specialist III) or more advanced classifications (e.g., Principal Senior Specialist).

These classifications are intended to apply to NCSS in general and to functional specialties (e.g., analysis), if used. Proposed classification-specific requirements are noted in general in a later part of this section and in more detail in section 5.2.2.3.

5.2.2.2.2.1 Entry. The Entry-Level classification is for personnel who meet selection criteria with a combination of education, experience, and training deemed sufficient to begin in the NCSS anticipated mode-of-progression. Individuals requiring remedial work may stay in the classification for an extended period of time. Personnel with experience elsewhere in the same facility or at another facility may be classified Entry-Level while verifying previous completion of applicable requirements and satisfying others.

It is most likely that any formal classroom training received by NCSS (including onsite classroom training, if warranted by candidate numbers and staff size) will be while in the Entry-Level classification. In addition, facility familiarization (e.g., in-facility assignments) and introductory projects such as for analysis/evaluation (e.g., a standard problem with a single computer code) and audit observation/participation are included.

Depending on the results of the analysis of jobs and tasks and on other factors including limited facility access for security clearance reasons, Entry-Level qualification may be divided along functional or other lines. In such circumstances, advancement to Apprentice status may be allowed, contingent on completion of deferred requirements prior to qualification as Specialist.

As the Entry-Level requirements are intended to provide qualification for beginning the Apprentice phase, this classification provides the basics of criticality safety, and of each of the functional specialties if such division is made.

5.2.2.2.2.2 Apprentice. The Apprentice classification is for personnel who have a combination of education, experience, training, and personal characteristics deemed sufficient to perform NCSS tasks under close guidance and supervision from, and with additional formal review (i.e., over and above that required by standard practices) by, a Senior Specialist, and who are able to participate productively in work activities in the specialty and related areas (defined in section 5.2.2.2.3).

The classification may be multiple level if Entry-Level requirements have been deferred, e.g., due to lack of facility access for security clearance reasons.

New hires may meet experience requirements for Specialist while in this category; experienced new-hire personnel spend only as much time as necessary to complete specific requirements.

An Apprentice may perform tasks in all or designated functional specialty area(s) under the guidance of a Senior Specialist. Such tasks include performing part of an analysis, running a computer code to assess subcriticality, participating in an audit, or preparing a draft regulatory or administrative document. Completion of Apprenticeship in the specialty and related areas, Entry-Level requirements in the remaining areas, and approval by management lead to Specialist status.

5.2.2.2.2.3 Specialist. The Specialist classification is for personnel with the education, experience, training, and personal characteristics deemed sufficient to perform NCSS tasks in all or

specialty area(s) independently, subject to normal technical and management review. Time-in-grade, acceptable work products, specialized training, leadership roles, and management approval lead to Senior Specialist status.

Personnel may meet experience requirements for Senior Specialist while in this category. Experienced personnel may spend a lesser amount of time consistent with meeting all other applicable requirements.

This is the minimum level of qualification allowing independent work. Depending on the size and extent of the facility, it may apply to specific functional specialties, particular subject area(s) within the specialty, or specific physical portion(s) or area(s) of the facility. The Specialist also may specialize further (e.g., risk analysis, code validation, human factors, or auditing) as appropriate to the collective competence of the organization.

The Specialist may act as a subject matter expert in areas of special competence for qualification of others (as directed by, and under the cognizance of, the designated Senior Specialist mentor). The work of the Specialist is subject to the usual reviews and quality assurance practices that are consistent with local procedures.

The Specialist will continue to have a Senior Specialist mentor. The quality of work products, specialized training, demonstration of sound judgment, initiative, leadership, and time-in-grade are measures of suitability for qualification as Senior Specialist. Although the subject areas are basically the same as those addressed as an Apprentice, attention shifts to increasingly independent action and to leadership and review related to the work of others.

A Specialist performs tasks in all or designated functional specialty area(s) and learns under the guidance of a Senior Specialist to provide oversight and quality assurance review of the work of others. Tasks subject to evaluation include performing and reviewing analyses, calculating and quality assuring computer calculations that assess subcriticality, leading an audit, or preparing regulatory and other administrative documents. Completion of Specialist qualification in all areas, or in a functional specialty, leads to Senior Specialist status.

5.2.2.2.2.4 Senior. The Senior Specialist classification is for personnel with education, experience, training, and personal traits deemed sufficient to perform NCSS tasks independently or in a leadership and oversight role. Personal traits (e.g., initiative, organization skills, integration ability, and maturity) are especially important to the specialist expected to work independently, train other specialists, provide review and approval of work products and documents, and, potentially, make "stop work" decisions (see section 5.1.1.9).

Senior Specialists perform routine final reviews and quality assurance of work originated by Apprentice, Specialist, and Senior Specialist personnel consistent with local procedures. They also act in a leadership capacity and, thus, shall be experienced enough to teach others how to do the job and take responsibility for the resulting work products.

The major qualification activities for Senior Specialists relate to demonstrating continuing competence. High-level technical training develops in-house expertise in specific subject areas. Management training supports increased leadership and eventual assignment as Lead Specialist, i.e., supervisor or manager.

5.2.2.2.2.5 Lead. The Lead Specialist classification is for personnel with education, experience, training, and personal traits deemed sufficient to supervise or manage the nuclear criticality safety function in general and NCSS tasks specifically. Significant personal traits include those desirable for Senior Specialists plus attention to such issues as demonstrated desire and ability prior to assignment and the ability and willingness to make decisions and be accountable for their results. It should be recognized that even outstanding technical specialists may not make good lead specialists and/or supervisors or managers.

Lead Specialist is a classification outside of the mode-of-progression. Its availability depends on organization staffing and structure and on the availability of organizational positions at given times.

If the supervisor or manager of a multi-disciplinary safety organization is not highly qualified in nuclear criticality safety, a subordinate Senior Specialist should be designated as Lead Specialist. The supervisor or manager should be qualified at least to the Apprentice level so as to be able to perform all basic NCSS tasks, albeit subject to a Senior Specialist mentor's guidance.

5.2.2.2.3 Functional specialization. If functional specialization is formalized, it is necessary that each NCSS qualify to a baseline level in all four functional areas in recognition of the interfaces described previously (e.g., the interactions among analysis, evaluation, implementation, and confirmation). Preferably this occurs during the Entry-Level classification, or if necessary, during Apprenticeship. The Apprentice is intended to be qualified to begin on a function-specific path in any of the four areas (under direct guidance and supervision of a Senior Specialist).

The qualification level for personnel specializing in each of the four generic functional areas is shown in Table 5.2.2.2.3-1. Consistent with the anticipated mode-of-progression, Senior Specialists qualify in their primary functional area, at least as Specialists in the designated related area, and at least as Apprentices in the two remaining interface areas. This approach recognizes the strong need for integration of the substance of the functional areas.

Table 5.2.2.2.3-1. Matrix of Qualification Levels for Each of Four Primary Functional Specialties.

Primary Functional Specialty	Qualification Level in Functional Area:			
	Analysis	Evaluation	Implementation	Confirmation
Analysis	**SENIOR SPECIALIST**	SPECIALIST	Apprentice	Apprentice
Evaluation	SPECIALIST	**SENIOR SPECIALIST**	Apprentice	Apprentice
Implementation	Apprentice	Apprentice	**SENIOR SPECIALIST**	SPECIALIST
Confirmation	Apprentice	Apprentice	SPECIALIST	**SENIOR SPECIALIST**

The analysis and evaluation functions are closely allied through the unique role of performing a criticality safety evaluation. Thus, practitioners of each need to be qualified at least as Specialist (i.e., capable of performing, though not necessarily overseeing, the work) in the related field. Being

qualified as Apprentice in the implementation and confirmation functions (i.e., capable of performing the tasks under close supervision of a Senior Specialist) recognizes the need to maintain close contact with the facility and to understand how analysis and evaluation results are implemented and how it will be verified that resulting requirements are met. The implementation and confirmation functions also must be called upon in support of developing analysis assumptions up front and ensuring that limitations identified by an analysis are implemented in the working environment. Double-contingency analyses, for example, and their documentation have both technical and administrative aspects.

Similarly, the areas of implementation and confirmation functions are closely allied and, thus, are related to each other. Implementation is a primary subject of the confirmation activities, with deviations and other identified weaknesses fed back for corrective action. Both require Apprentice-level familiarity with analysis and evaluation to assist effectively in specification of input assumptions; translate output conditions to practical in-facility methods (e.g., procedures, postings, etc.); and verify compliance/consistency between the evaluation (input assumptions and results), materials and equipment, and practices.

5.2.2.2.4 Continuing competence. Continuing competence of the Senior Specialist is maintained by performing routine tasks in the functional specialty and ensuring periodic performance of important tasks in the related and interface areas. The resulting work products are subject to routine peer evaluation and supervisory/management oversight or, if appropriate, to special evaluation.

Continuing competence is the long-term qualification program for Senior and Lead Specialists. Entry-Level, Apprentice, and Specialist personnel maintain qualification through satisfactory progress in the anticipated mode-of-progression.

5.2.2.2.5 Requirements. Requirements for NCSS are a combination of education, experience, formal training, structured on-the-job training, professional development, and personal characteristics. As with any professional position, each NCSS may be expected to achieve qualification through a personalized program that addresses specific strengths and weaknesses. General trade-off equivalencies among the qualification factors identified in this section should be specified in the qualification procedure. Management should document the bases for each specific application.

Minimum entry-level standards or selection criteria are identified for new hires. A technical background is required, consistent with the nature of the NCSS tasks.

Exceptions to requirements (e.g., experience in lieu of degree, credit for advanced degree, or degree-related criticality safety experience) should be documented.

DOE Order 5480.20, "Personnel Selection, Qualification, Training, and Staffing Requirements at DOE Reactor and Non-Reactor Nuclear Facilities" (2-20-91) does not address nuclear criticality safety specialist personnel specifically. However, the NCSS are considered non-reactor nuclear facility technical support personnel who, according to the Order, have duties that include involvement in surveillance, analyzing facility data, planning modifications, program review, and technical problem resolution in their area of expertise (e.g., nuclear criticality safety). The Order establishes baseline education and experience requirements for general technical support personnel. It also dictates that when a specific position is equivalent to one defined for category-A reactor

personnel, the requirements for the latter apply. Although the NCSS position is not directly equivalent, it has similarities to that of the category-A reactor technical support personnel and, to a lesser extent, to that of the reactor engineer.

Table 5.2.2.2.5-1 compares the relevant education and experience requirements for class-A reactor and non-reactor nuclear facility personnel with those established for NCSS in this standard. Each entry applies to what the Order refers to as "positions with authority to review and concur, and not to entry-level positions." Thus, the proper NCSS comparison is to the Senior Specialist. All positions have the same education requirement, while according to DOE Order 5480.20 the reactor and non-reactor nuclear facility technical support positions have the same experience requirement, and that for the reactor engineer is greater. The Senior Specialist experience requirement is greater than that for general technical support personnel both in being three years and facility-specific (or equivalent as developed in section 5.2.2.2.5.2). Thus, minimum nuclear and onsite experience requirements, which also may depend on functional specialization and other qualification factors, are not specified separately.

Table 5.2.2.2.5-1. Education and Experience Requirements from DOE Order 5480.20 for Reactor and non-Reactor Facility Personnel Compared to Those for NCSS Personnel.

Position / Requirement	Category A Reactor – – – Technical Support*		Non-Reactor Nuclear Facility – – – Technical Support*	Nuclear Criticality Safety (Senior) Specialist
	General	Reactor Engineer		
Education	Baccalaureate degree in engineering or related science	Baccalaureate degree in engineering or related science	Baccalaureate degree in engineering or related science	Baccalaureate degree in engineering or related science
Experience				
Job-Related	2 years	4 years	2 years	3 years**
Nuclear	1 year	2 years	1 year	***
Onsite		6 months		***

* SOURCE: DOE Order 5480.20, "Personnel Selection, Qualification, Training, and Staffing Requirements at DOE Reactor and non-Reactor Nuclear Facilities" (2-20-91)

** Equivalent site-specific nuclear criticality safety experience

*** Minimum nuclear and onsite experience not specified, as explained in the text

NOTE: General trade-offs between education and experience are allowed by DOE Order 5480.20 and as delineated in the body of this standard.

5.2.2.2.5.1 Education. The minimum qualification or selection criterion for education is the baccalaureate degree in an appropriate technical field (e.g., engineering, physical science, human factors, etc.).

For each functional specialty, some degree disciplines may be more applicable than others, e.g., chemical engineering for analysis in a "wet chemistry" facility, nuclear engineering or physics for evaluation, and human factors engineering for implementation and confirmation. Other curricula

should be evaluated case-by-case, with experience or training requirements increased if appropriate.

For those lacking a degree in an appropriate technical field, holding an associate (2-year) degree, or holding a baccalaureate degree in a non-technical field, equivalence may be established on-the-job through apprenticeship with a Senior Specialist as mentor. Experience and training requirements should be increased accordingly. Applicable experience should be accumulated at the level of tasks performed by degreed NCSS personnel and comparable to job requirements in designated functional specialty and physical areas. Equivalence to the technical baccalaureate degree may be judged in terms of experience at the Apprentice level and demonstrated ability to perform tasks required of the NCSS.

An advanced degree or applicable graduate work as an indication of additional analytic ability or maturity may be judged to reduce the experience requirement. Specific studies or research related to criticality safety also may be applied to reduce training or professional development requirements as appropriate.

Specific educational background appropriate to specialization -- e.g., probabilistic risk assessment for analysis, reactor physics for evaluation, human factors for implementation and confirmation -- may also be acquired through training and professional development. Overall, factors such as area of study, level, and other considerations may be applied to adjust experience, training, and apprenticeship requirements.

5.2.2.2.5.2 Experience. Direct nuclear criticality safety experience at the given facility sets the baseline standards -- one year for Specialist and two additional years (total of three years) for Senior Specialist. The Lead Specialist classification generally requires experience beyond that of the Senior Specialist, although as described above it is not part of the mode-of-progression. The minimum experience requirements may be adjusted according to educational background factors.

New-hire personnel accumulate experience while participating in the anticipated mode-of-progression. Previous experience may reduce the requirements. Facility personnel who have performed jobs most directly associated with nuclear criticality safety receive the greatest credit. For those who have worked at one or more other facilities, direct nuclear criticality safety experience is most directly applicable. Experience that is nuclear related (e.g., reactor fuels, reactors, safety analysis, health physics, industrial safety, or similar disciplines at the same or other similar facilities) should be evaluated with credit given in relationship to applicability to general and specific NCSS tasks. However, even if all experience requirements are judged to be met, the individual shall still complete all facility familiarization requirements, demonstrate equivalence to specific training requirements, and complete and have evaluated a designated number of "projects" (e.g., work products of the type included in the apprenticeship program and used as the basis for judging continuing qualification).

5.2.2.2.5.3 Training. Formal training courses may be developed for Entry-Level qualification and for later activities as appropriate to the size of the facility organization. Such courses should be performance-based, consistent with the guidance of ANSI/ANS-8.20-1991 (even though training of NCSS personnel is not addressed explicitly). Subject matter recommended by ANSI/ANS-8.20-1991 will be addressed, though at greater depth consistent with the needs of the NCSS audience. Course formats other than lecture, e.g., seminars, workshops, etc., are preferred.

Consistent with ANSI/ANS-8.20-1991 and performance-based training, evaluations of candidate performance should be conducted. A comprehensive written examination is one alternative, although realistic problem solving activities that demonstrate both knowledge and ability to apply it appropriately may be the better choice. Open-book exercises such as applying ANSI/ANS standards, guides, and other reference materials are appropriate.

Many offsite courses are appropriate for Entry-Level and more advanced qualification. Such courses should be evaluated for applicability based on characteristics including subject matter, faculty breadth and expertise, audience makeup (e.g., peers and other contacts at similar facilities), and instructional approach (lectures, workshop sessions, and practical exercises). Whether a formal evaluation of participants is provided, it should be verified independently (e.g., through the Senior Specialist) that the desired learning has taken place. Value beyond subject matter is recognized due to interactive activities with faculty and peers from other facilities.

Applicable offsite courses include the general short courses offered by the University of New Mexico and Los Alamos National Laboratory's critical facilities. Broad or specialized courses on safety analysis, computer and other computational methods, audits and inspections, human factors, and other related subjects also deserve consideration.

An appropriate mix of onsite and offsite training courses, refresher seminars, and workshops can provide the NCSS with knowledge that will support development and maintenance of requisite facility-specific skills.

5.2.2.2.5.4 On-the-job training. As with other professionals, the NCSS performs basic recurring tasks that are similar, but not repetitive in the sense of those performed by production-oriented operators and technicians (e.g., analyses using the same methods, but each time for a different situation). Likewise, individual NCSS, even new hires, have differing needs for qualification. Thus, formal training courses generally are less appropriate than learning-by-doing. A structured on-the-job training (OJT) approach is indicated for this purpose. The OJT mode of qualification can be applied from entry level through continuing qualification, with most direct use during the Apprentice and Specialist classifications. In all cases the training proceeds under the close supervision and guidance of a Senior Specialist.

On-the-job training, whether standardized or individually orchestrated, is primarily one-to-one (or one-to-a-few) between the candidate(s) and a Senior Specialist. Work performed by the candidate (prior to qualification as Specialist) is subject to careful supervision by the Senior Specialist and to routine peer review, as applicable. Senior Specialists serve as mentors. Subject matter experts (SME) qualified and experienced in performing a particular task may, on a case-by-case basis, be assigned by the Senior Specialist to direct, observe, or evaluate performance of activities. Periodic evaluation of candidate performance is required.

On-the-job training depends heavily on individual initiative of the NCSS candidate and uses directed self-study -- a training setting without a full-time instructor in which objectives and conditions are provided by the Senior Specialist, using training materials, or in-facility reviews and instruction. A qualification checklist, "card" file, or other means (for simplicity, hereafter referred to as the checklist) may serve as the basis for directing and documenting progress and completion of designated milestones. Activities that are the means for judging completion of specific tasks include

- Review -- deliberate critical examination of references and training materials,

- Observe -- directed careful analytic attention to the performance of another,

- Perform -- performance of actual or equivalent tasks using necessary references, materials, and tools in the normal job environment, and

- Simulate -- mimicking task performance at the job site or through task performance on a mock-up device similar to the actual equipment and work environment.

For activities such as review of documents and observation of facility evaluations, which do not automatically generate a work product that is subject to review by a Senior Specialist or subject matter expert, an appropriate performance evaluation technique is required. This may take the form of a documented discussion -- explanation or other techniques of evaluation that indicate proficiency -- with the Senior Specialist, a more formal evaluation, or a written examination. Workbooks or notebooks that can be reviewed by the Senior Specialist or others also are appropriate. In all cases it is necessary to document qualification details using the checklist.

The on-the-job training requires performance-based development, i.e., systematic determination of specific tasks, task analysis for skills and knowledge, and learning objectives that define the expected content and level of performance.

Exemption from, or reduction in, requirements (e.g., fewer analyses, evaluations, or audits) may be based on previous experience, but preferably on proficiency testing or work-product review.

Evaluation modes may include

- Board evaluations based on oral, walk-around, notebook review, or other demonstration; these may in turn be divided into

  - Mini-boards with the Senior Specialist and a supervisor or subject matter expert, as appropriate, to judge intermediate milestones, and
  - Final board with, at a minimum, the Senior Specialist, supervisor/manager (chair), a designated SME, and a "facility" representative; other senior specialists also may be included;

- Projects that test technical ability, judgment, etc. reviewed by teams composed similar to the boards; the process may be accompanied by a final oral "defense" (or board) evaluation.

Board members should receive training on conduct and participation in the process. The chair and/or Senior Specialist should receive more detailed training on board setup and conduct.

Where seminars, workshops, and offsite courses (see also section 5.2.2.2.5.3 on Training) are used as a basis for meeting what is otherwise an OJT task, the content (i.e., the learning by the candidate) should be evaluated for applicability using the standard OJT processes.

5.2.2.2.5.5 Professional development. Professional development activities apply to all classification levels and are a major element in Senior Specialist initial qualification and continuing

competence. They are subject to review with the Senior Specialist, supervision, or others. Presentation of a seminar may be an appropriate way both to verify the extent of learning and to share the experience with peers.

Professional development activities include, but are not limited to,

- educational activities and technical meetings such as conferences, seminars, clinics, workshops, tours, forums, or symposia,
- college courses (including home study),
- professional development courses,
- onsite workshops or seminars,
- publication of papers, reports, or other peer-reviewed documents,
- special onsite and offsite work assignments (e.g., task force membership or a temporary in-facility assignment),
- preparation of a position paper for critical review on a contentious issue of nuclear criticality safety,
- intra-site committees (e.g., safety overview),
- inter-site committees (e.g, multi-site corporate, DOE-regional, or DOE-wide), and
- regional or national committees (e.g., American Nuclear Society Nuclear Criticality Safety Division, Institute of Nuclear Materials Management, ANSI/ANS-8 Standards).

In each case, active participation (e.g., as instructor, chair, or officer) carries more credit than mere attendance.

5.2.2.2.5.6 Personal characteristics. The qualification process should include on-going evaluation and judgment of the readiness of the NCSS candidate to do the whole job and do it independently. The Senior Specialist should address such issues during the course of the process. Management has the prerogative on the final judgment based on factors that can include the candidate's judgment, technical ability, and initiative. As noted previously, each Senior Specialist may have review, approval, and/or "stop work" authority (e.g., in section 5.1.1.9) and, thus, needs to be judged capable of implementing them.

5.2.2.2.6 Overall qualification. The qualification process may be coordinated through the use of a qualification checklist. This may be a generic form that is readily customized to needs of individual NCSS candidates. Where functional or other specialization is employed, the checklists may be tailored appropriately. The checklist should provide guidance on the tasks to be performed and the means by which the NCSS will be evaluated (i.e., objectives).

By implementing a formal qualification program for the first time, existing personnel use a qualification-by-*documentation* approach with the same checklist. They

- indicate education, experience, etc.,
- indicate how training/task requirements were met and equivalence to Entry-Level and Specialist programs,
- establish a schedule for meeting any serious deficiencies, and
- focus primarily on the continuing competence requirements to verify their ability to perform major work-product tasks.

For new or existing personnel, exceptions to formal qualification requirements may be made based on judgment and documented alternatives (e.g., experience in lieu of a degree or credit for an advanced degree, specialized course work, or relevant research activity).

The process should have provisions for final confirmation of competence made by safety supervision or management (and, if applicable to a specific facility, by cognizant line management). A comprehensive written examination, oral or facility walk-around examination, or a combination thereof, should be used to address all major NCSS tasks. Evaluation of realistic and representative work products should be an important part of the process. Remedial actions for failures need to be specified.

5.2.2.3 Classification-specific qualification programs. Subject-matter content for the NCSS qualification program should be developed from an installation-specific analysis of the job and its tasks. The analysis may be used to designate functional specialties. Each facility has the option to use the generic classification levels proposed in this document or use site-specific classifications consistent with its human resources system.

An acceptable approach to developing a classification-specific qualification program is provided in Appendix A.

5.2.2.4 Functional-specific qualification programs. If functional specialization is employed, the analysis of the job and its tasks should be used to make an installation-specific check list. As described in the previous section, these may apply to all of the Entry-Level, Apprentice, Specialist, and Senior Specialist classifications at progressively more detailed levels. Additional specialization may be employed with respect to the collective capability of the organization.

An acceptable approach to providing content for a functional-specific qualification program is provided in Appendix B.

5.2.2.5 Continuing competence. Continuing competence demonstration is required of each Senior Specialist. It is addressed here rather than with the classifications due to the tie-in to the four functional specialty areas.

Existing personnel or highly experienced new-hires who have been performing at the Senior Specialist level employ a qualification-by-documentation approach as described previously (section 5.2.2.2.6). A Senior Specialist who is a peer should be assigned to validate or verify basic and continuing competence requirements.

Those designated as Apprentice or Specialist are not specifically subject to these requirements with normal progress in the qualification mode-of-progression. However, comparable activities and consistent frequencies should be included on the qualification checklists.

The actual content of the program to ensure continuing competence should be derived from the analysis of the job and its tasks. General areas and issues are addressed below.

Periodic training in technical and administrative subjects assists in maintaining and improving job performance and developing broader scope and depth in specific knowledge and skills. Retraining on subjects included in the Entry-Level, Apprentice, and Specialist portions of the qualification program is generally not necessary. However, if individual or group performance problems are identified, they should be addressed. Specific subjects that are appropriate for continuing training include, but are not limited to,

- facility and industry operating experience, audit findings, and deficiency trends,
- changes to systems, components, and applicable procedures,
- changes to DOE Orders, National Standards, and other guidance, and
- major changes to NCSS tasks.

Classroom training, seminars, or "required reading" may be appropriate methods. Examinations, discussions, or evaluation of work products should be used for confirmation consistent with the approaches applied in mode-of-progression qualification.

Continuing competence requirements are based on performing activities in each of the four functional areas (including all required reviews and approvals for the designated level, with additional review if appropriate). The requirement may be annual or graded based on functional specialization (e.g., annual for the specialty area, biennial for the related area, and triennial for general or interface areas). Work products should be provided and evaluated in each of the following areas:

- facility familiarity (e.g., through periodic tours and meeting attendance);
- analysis for criticality safety (e.g., double-contingency analyses);
- evaluation of subcriticality;
- facility audit activities;
- implementation activities, e.g.,
  - task, job, and procedure audits,
  - investigation of criticality safety limit violations, and
  - evacuation procedure audits;
- onsite professional development activity, e.g.,

- regular task, but elsewhere in the facility or with a different organization, and
- appropriate activity from the list in section 5.2.2.2.5.5 or equivalent; and

- offsite professional development activity (e.g., see section 5.2.2.2.5.5).

For large facilities where qualification may be based on physical areas or processes, the requirements apply to each applicable area.

Where functional specialization is used, each work product may be geared according to the specialization and classification shown in Table 5.2.2.2.3 as follows:

- specialty field at the Senior Specialist level -- lead an analysis, evaluation, or audit effort; review and quality assure analyses, evaluations, or audits; or complete major administrative responsibilities;

- related field at the Specialist level -- perform a new and original analysis, evaluation, audit, or administrative task; and

- general/interface fields at the Apprentice level -- perform (under supervision) representative analysis/evaluation exercises or participate in audits and administrative tasks.

5.2.2.6 Documentation and records. Documentation shall be maintained on the qualification of each NCSS. The qualification checklist or equivalent documentation may be designed to serve this purpose. It should show each applicable task, how and when it was accomplished, examination results if applicable, and who verified completion (of single tasks or groups of tasks). Final approvals by the Senior Specialist and supervision/management should also appear.

Records shall be developed consistent with facility policies and procedures for training and qualification. Retention of documentation and records shall be consistent with DOE Orders and facility procedures.

5.2.2.7 Evaluation. Evaluations of the NCSS qualification program and personnel should be performed and documented periodically. Documentation of these evaluations should be retained in accordance with the applicable document listed in section 2.1.2. Additional documentation requirements are provided in the applicable document listed in section 2.1.9.

5.2.3 Visitors and Clerical Employees. As a minimum, visitors and clerical employees entering fissionable material control areas should have been instructed in the identification of the criticality accident alarm system (CAS) signals (audible and/or visible), instruction on the requirement for immediate evacuation if in an area in which a CAS alarms sounds, identification of evacuation routes, and an explanation as to why a CAS alarm is necessary. These persons shall also have been instructed to refrain from all actions involving the movement, processing, or storage of fissionable material.

5.2.4 Auditor Qualifications. Nuclear criticality safety program auditors shall have adequate education, knowledge, training, and experience to review and evaluate the elements of a nuclear criticality safety program in terms of content and adequacy for its intended application.

5.2.4.1 Compliance. A compliance auditor of a nuclear criticality safety program shall have a demonstrated basic knowledge of DOE Orders, associated statutory requirements, and industry standards and practices in order to recognize the equivalency or adequacy of documented and observed program procedures and practices (i.e., compliance) with the DOE Orders. This knowledge shall be demonstrated by either

- three years in the administration and management of a non-reactor nuclear facility nuclear criticality safety program, or
- education, training, and testing (developed from job/task analyses) in the above subject matter.

5.2.4.2 Quality Audit. An auditor of nuclear criticality safety program quality shall have broad knowledge and applications experience (minimum of seven years) with specific experience in the particular subject to be audited. Examples of this specific experience may include, but are not limited to,

- physicochemical operations and administrative controls used in the processing, handling, transport, or storage of fissionable materials, and typical or experiential upset/contingent conditions of these operations,
- computational physics as it relates to computational modeling, use and/or processing of neutron cross sections, and computer code verification and validation,
- safety analysis techniques such as failure modes and effects analysis, what-if analysis, management oversight risk tree analysis, etc.,
- human factors influences on processes,
- conduct of inspections, self-assessments, and audits,
- emergency preparedness, and
- criticality safety training subject matter for operators, supervisors, managers, visitors, etc.